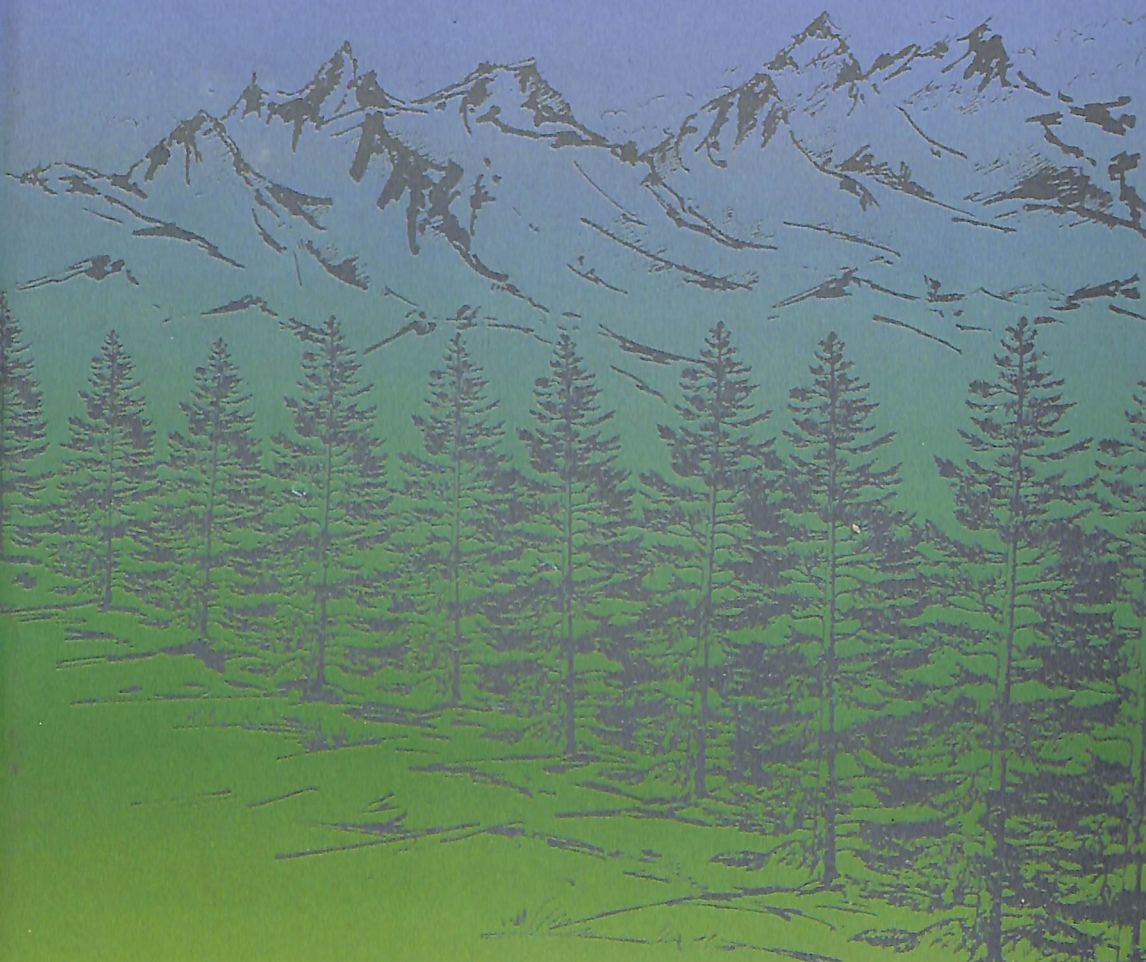


SECOND REVISED EDITION



*Himalayan
Forests and
Forestry*

S.S. NEGI

HIMALAYAN FORESTS AND FORESTRY

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INDUS
PUBLISHING COMPANY

Preface

The Himalaya, stretching from Jammu and Kashmir to Arunachal Pradesh, is the most magnificent feature on the face of the earth. It supports rich and diverse forests varying from the rain forests of the eastern Himalaya to the cold desert vegetation of Ladakh, Lahaul and Spiti. Thousands of different species of trees, shrubs and grasses occur in the Himalayan region.

Himalayan forests play a dominant role in the lives of the millions of people living in this complex mountainous system. It supplies them with fuel, timber, raw materials for cottage industries and fodder for their cattle. On the environment front, the Himalayan forests help to preserve civilization in the entire Indian subcontinent as they prevent the fragile soil covering the steep mountain slopes from destroying vast tracts of agricultural land in the food-growing regions of the Indo-Gangetic plain.

The book deals with various aspects of forests and forestry in the Himalayan region. It includes chapters on forest types, important trees, forest policy, forest law, forest products, regeneration, management and protection of forests, besides forestry research and participatory forest management.

The author is thankful to his friends and well-wishers for their encouragement; to his family for their self-denial; and to the publishers for bringing out the second revised edition of this book.

SHARAD SINGH NEGI

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1

The Himalaya: An Introduction

The Himalaya is a part of the complex system of folded mountain chains radiating from the Pamir Knot. The others, including the Kun Lun, Sayan, Lin Shan and Tein Shan spread out in different parts of Tibet, Iran, Afghanistan, Pakistan, India and Central Asia. This mountain chain extends for a length of about 2400 kms from the Nanga Parbat massif in the north-west to the Namche Barwa peak in the east. Between these two peaks, this complex mountain chain consists of deep gorges, narrow valleys, boulder-strewn glaciers, fertile terraces formed by rivers and tree-clad slopes. The Himalaya lies within India, Nepal, Bhutan and Tibet.

PHYSIOGRAPHIC DIVISIONS

This mountain chain is believed to have been formed due to different episodes of tectonic activity. The Himalaya was once under the sea lying between the Tibetan landmass in the north and Indian landmass in the south. Rivers from both these landmasses emptied themselves into the sea. Thick deposits of sediments were deposited on the sea floor over millions of years. The northwards movement of the south Indian landmass brought pressure on these sediments and they gradually rose from under the sea to form the Himalayan mountain chain. This process took billions of years and the uplift of the Himalaya occurred in three to four distinct phases. Each of these phases formed a mountain chain different from the others.

The Himalaya is divided into four distinct regions (from south to north). These are believed to have been formed by distinct phases of uplift of the Himalaya from under the sea.

1. Shiwalik Hills

These are low rolling hills lying parallel to the main Himalayan arc. The

Shiwalik hills are the youngest formation of this mountain chain. These hills are very well developed in the western and central Himalaya but they gradually merge with the lower Himalaya in the east. The Shiwalik hills may rise to an elevation of over 1000 mts.

2. Lower or Lesser Himalaya

The lower Himalaya is made up of a series of mountain ranges lying to the south of the main Himalayan range. Longitudinal valleys known as the *dun valleys* separate the lower Himalaya in the north from the Shiwalik hills in the south. Some examples of the dun type valleys are the Dehradun and the Kiarda dun. The lower Himalaya usually rise abruptly over the Shiwalik hills, e.g. the Mussoorie ridge. Its southern slopes are steep which suggest that the forces that led to their uplift from under the sea came from the south. The lower or lesser Himalayan ranges tower to elevations of over 3000 mts.

3. Higher or Main or Central Himalaya

This is the main Himalayan range which forms the core of this complex mountain chain. It is an arc-shaped wall forming the periphery of the Himalaya. Very high mountain peaks form a part of the higher or main Himalaya, the highest being Mount Everest in Nepal. Most of the peaks of this part of the Himalaya are under permanent cover of snow.

4. Trans or Tibetan Himalaya

This part of the Himalaya lies across the main Himalayan mountain wall. It is a high tableland with an elevation of over 4000 mts. Conditions resemble those found in Tibet. The trans-Himalaya experiences a typical central Asian climate. Lahul, Spiti and Ladakh lie in the trans-Himalaya.

CLIMATE

Dyhrenfurth has described the Himalaya as the *third pole*. This mountain chain experiences a wide variety of climatic conditions which range from the very high rainfall areas of Arunachal Pradesh to the temperate regions found at higher elevations and finally to the cold deserts of the trans-Himalaya.

The basic patterns of weather and climate over the Himalaya are influenced by the conditions prevailing in the rest of the Indian subcontinent though the climatic conditions of the trans-Himalayan zone

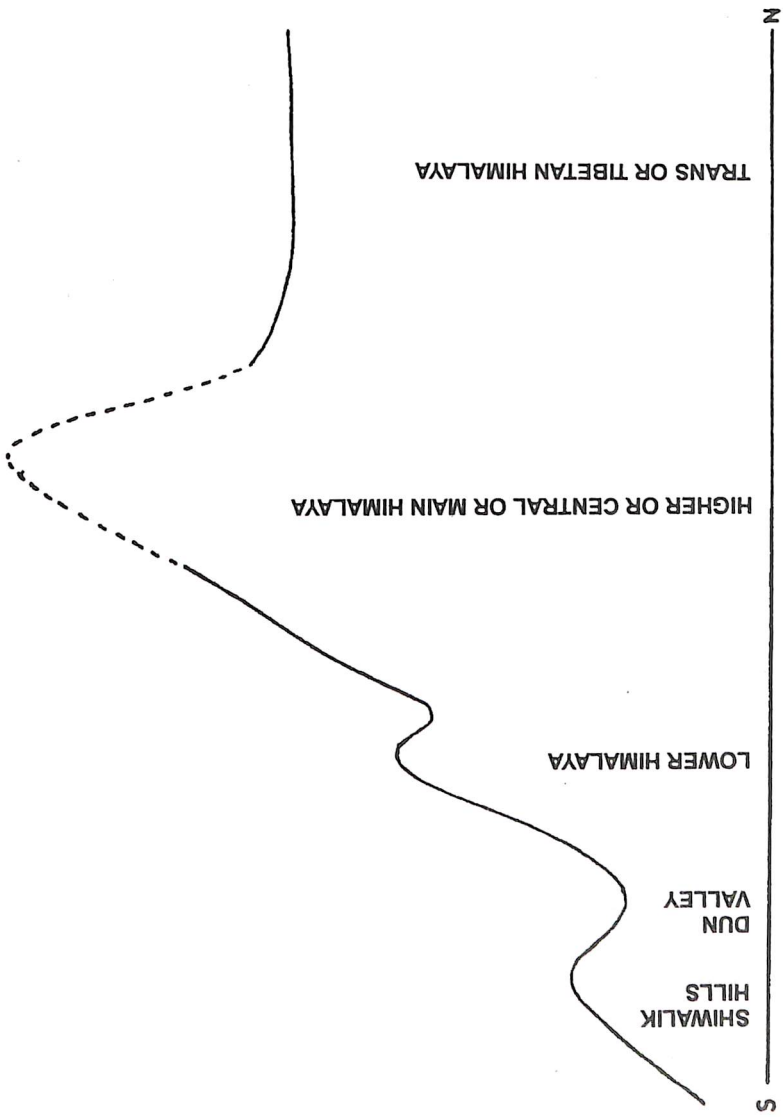


Fig. 1. Physiographic section across the Himalaya.

are governed by the climate of central Asia. Gigantic land and sea breezes originating from the Bay of Bengal, Indian Ocean and Arabian Sea blow across the Indian subcontinent with clock work regularity once each year. These give rise to the famous south-west monsoons which bring widespread rain to most parts of India including the Himalaya. Due to the intense heat of the summer months, a very high temperature zone is formed over the heart land of India. The mercury may soar to over 42°C and this forces the hot air to rise and a low pressure zone is formed with a corresponding high pressure zone over the surrounding mass of water. Moisture-laden winds blow into this low pressure zone. These are the SW monsoons which bring rain to most parts of India in the post-summer season. The SW monsoons strike the Himalaya and cause heavy rains. This phenomena is reversed during the winter months and winds blow in the opposite direction bringing winter rains to different parts of the Himalaya.

However, some parts of the Himalaya are not influenced by the general climatic conditions prevailing in the other parts of this mountain chain. The Kashmir valley is bounded on all sides by very high mountains. The moisture-laden winds from the south are unable to cross these high mountain walls and hence the Kashmir valley experience peculiar climatic conditions. There are large waterbodies within this valley and these generate local moisture-laden winds which cause rain all over this valley. The trans-Himalayan zones lie in the rain shadow of the main or central Himalaya. The SW monsoons are unable to cross the main Himalaya. Thus the trans-Himalayan zone is, by the large, dry with scanty rainfall.

Cycle of Seasons

The Himalaya experiences the following well defined climatic seasons.

1. *Summer*: The summer season in the Himalaya begins from about the middle of April and continues till mid-June when the SW monsoon cause widespread rain. The summers are shorter in the eastern Himalaya as the monsoons reach there earlier.

It becomes extremely hot in all parts of the Shiwalik hills and the lower Himalaya and in the valleys of the higher Himalaya. The day temperatures soar to over 35°C in this tract. The areas lying near the snowline are relatively cooler. In the foothills of the western Himalaya, dust from the Indo-Ganga plains rises up and covers the sky. This reduces the visibility to almost zero.

2. *Monsoon*: The SW monsoons cause widespread rain in most parts

of the Shiwalik hills, the lower and higher Himalaya from the end of June to the end of September. The monsoons bring relief to this tract which is reeling under the intense summer heat.

The rains are very heavy on the southern slopes of the Himalaya. It may continue for several days at a stretch in many areas. Vast areas are covered under a thick blanket of mist for long periods during which the sun rarely comes out. Widespread havoc is wrought by the monsoon rains as roads and bridges are washed away in the flash floods, and landslides disrupt normal life.

The higher Himalayan range prevents the moisture-laden monsoon clouds from crossing over to the trans-Himalayan zone. Thus, these tracts are largely dry and remain devoid of rain during the monsoons.

3. *Autumn*: The monsoon rains stop in mid-September or early October. The weather clears up and bright sunny days bring relief from the prolonged spell of rains. Autumn is considered to be the best season in the Himalaya. The weather remains excellent in most parts of this mountain chain except at very high elevations where winter quickly sets in and the first snowfall of the season may occur in late September.

Autumn continues till the end of November after which the long Himalayan winter sets in. Occasional showers mar the fair weather towards the end of the autumn season.

4. *Winter*: The Himalayan winter is fairly long and dull. It sets in late November and continues till the end of February or the middle of March. Snowfall is fairly common in most parts of the Himalaya lying above an elevation of about 2300 mts. The snow may lie on the ground for several weeks at a stretch. The temperature commonly remains below the freezing point in many parts of the higher and trans-Himalaya. Frost occurs in winter in the valleys of rivers and streams. Late winter frost may occur as late as in mid-March. Winter rains are common in all parts of the Himalaya.

5. *Spring*: This season brings relief from the long, dull winter of the Himalaya. Spring begins from early or mid March and continues till the arrival of the summer season in mid or late April. This season marks the transition from winter to summer. The weather is largely clear in the eastern Himalaya while local disturbances occur during spring in the western and central Himalaya. Late winter frost occurs in the early part of spring in the western Himalaya. However, days are sunny and clear and nights festooned with stars.

Gravity Winds

Gravity winds are a common feature in most parts of the Himalayan mountain chain. Towards sunset, there blow downward winds due to changes in temperature and pressure conditions. These winds take with them cloud and mist into the valley. At daybreak and early morning, a reverse wind blows from the valley to the top of the mountains.

Climatic Regions

The following parameters are used to delineate the Himalaya into climatic regions. These are:

- (a) prevailing climatic conditions, viz. precipitation (rain and snow), temperature, frost etc.
- (b) altitude or elevation
- (c) latitude
- (d) topography or physiography and aspect.

On the basis of above parameters, Negi (1985) has recognised the following climatic regions in the Himalaya.

Region	Altitudinal Range (in mts above sea level)
<i>Western Himalaya</i>	
Arctic	over 4500
Sub-arctic	3500-4500
Temperate	2000-3500
Sub-tropical	700-2000
Tropical	below 700
<i>Central Himalaya</i>	
Arctic	over 5500
Sub-arctic	4500-5500
Cold temperate	3500-4500
Cool temperate	2000-3500
Warm sub-tropical	700-2000
Warm tropical	below 700
<i>Eastern Himalaya</i>	
Arctic	over 6000
Sub-arctic	4800-6000
Cold temperate	3800-4800

Cool temperate	2200-3800
Warm sub-tropical	800-2200
Warm tropical	below 800

GEO-POLITICAL SETTING

The geo-political regions of the Himalaya with their administrative units have been discussed in brief.

Jammu and Kashmir

The state of Jammu and Kashmir occupies the north-western part of India and is made up of the following physical units:

(a) *Karakoram range*: The Karakoram range and adjoining tract lies to the north of the main Himalayan and Zaskar ranges in the Ladakh region of the state. The elevation of more than 10 peaks exceed 7000 mts. with the prominent ones being K2, Gasherbrum, Dast-i-Ghil and Saser-Kangri. The average elevation of this region is more than 3000 mts. Bulk of the precipitation is in the form of snow. Some of the highest glaciers in the world lie in this region with the most prominent one being the Siachen glacier. The Karakoram range is sparsely populated, due to the high elevation and harsh conditions prevailing in this tract.

(b) *Gilgit valley*: This is a fertile valley lying in the north-western part of the state, being drained by the Gilgit river and its tributaries and draining into the Indus. High mountain peaks with elevations of over 7000 mts. surround the valley.

(c) *Ladakh plateau*: This is a vast tableland lying across the main Himalayan range with an average elevation of more than 3500 mts. A number of prominent river valleys and salt encrusted lakes form a part of Ladakh. The Indus river and its many tributary systems drain this region. The Soda plains and Aksai Chin are a part of this region. Ladakh is an almost treeless region, with a considerable portion of the landmass being covered under a permanent cover of snow. Agriculture is limited to the valley areas where human settlements are common.

(d) *Zaskar range*: The Zaskar range is another trans-Himalayan mountain range of the Ladakh region, being a desolate tract formed by high mountains, river valleys, glaciers and barren plains. The eastern part of this tract is known as the Rupshu of which the famous Tso-Morari lake forms a part.

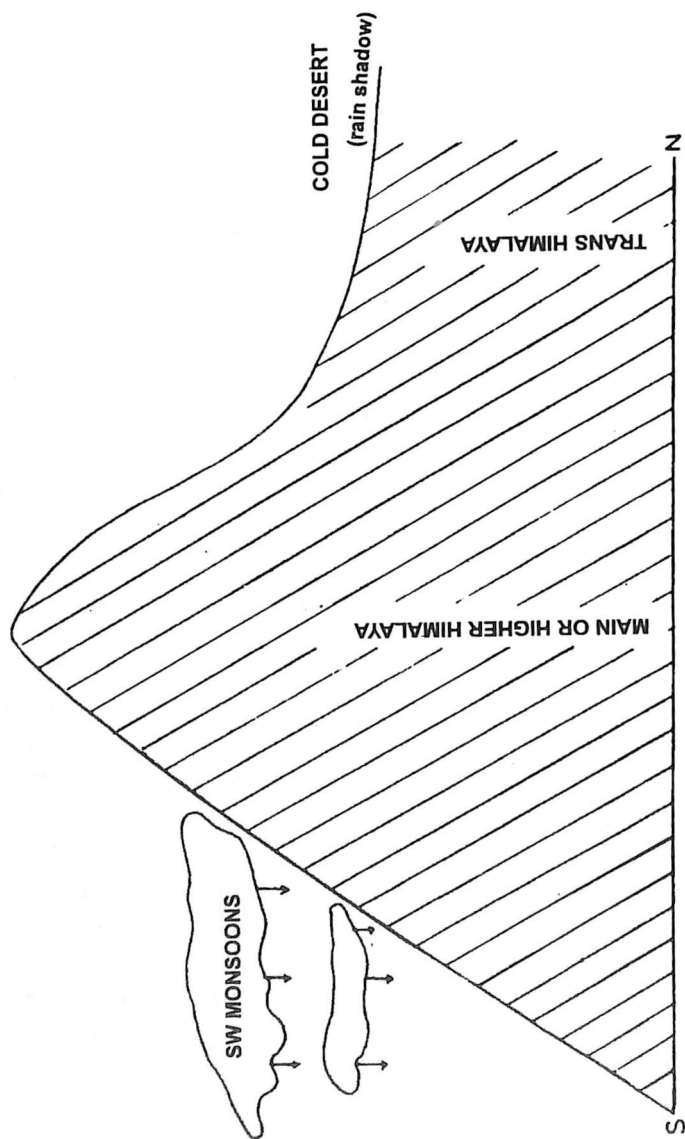


Fig. 2. Rain shadow effect of the main Himalaya.

(e) **Main Himalaya:** The main or great Himalaya range branches off from the Nanga Parbat massif and runs in an arc passing along the northern part of the Kashmir valley and to the south of the Zaskar range towards south-east into Himachal Pradesh. It is formed by high mountain peaks. Important passes across the main Himalayan mountain wall are the Burzil La and Zoji La.

This range is made up of snow-clad peaks, glaciers and deep river valleys. In Himachal Pradesh, it has been cut across by two rivers which rise in the trans-Himalayan region, viz. the river Chenab and Satluj.

The great or main Himalayan range forms the northern border of Garhwal and Kumaun. It consists of a number of very high peaks such as the Chowkhamba, Nilkanth and Nanda Devi. A number of major rivers rise from the base of this range. These include the Liddar, Beas, Ravi, Yamuna, Bhagirathi, Mandakini, Alaknanda, Nandakini and Pindar.

(f) **Kashmir valley:** The famous valley of Kashmir is broad, open and fertile, having once been the basin of a great lake whose remnants exist today in the form of the Wular, Dal and Nagin lakes. This valley lies between the great or main Himalayan range in the north and the Pir Panjal mountain range in the south. It is drained by the Jhelum river and its tributaries and has many important lakes. The Kashmir valley is very fertile and comprises of important towns like Srinagar and Anantnag.

(g) **Pir Panjal range:** The Pir Panjal range runs along and arc forming the southern boundary of the Kashmir valley. The jagged peaks forming the Pir Panjal remain covered under snow all round the year and rise to an elevation of over 3000 mts (the snowline being lower in the western Himalaya). The rivers Jhelum and Chenab have cut across this mountain range.

Towards east, the Pir Panjal enters Himachal Pradesh and gives way to the *Dhauladhar range* which towers above the plains of Punjab. Further towards east, this range gives rise to a number of mountain ranges of the lower or lesser Himalaya. This includes: the Nag Tibba range; the Shimla hills; the Churdhar ridge; the Mussoorie ridge; the Pauri ridge; and the Nainital hills.

(h) **Shiwalik hills:** The Shiwalik hills occupy a very wide tract in the state comprising primarily of the Jammu region. These are relatively low hills running parallel to the Pir Panjal range and merging with the Shiwalik hills of Himachal Pradesh in the east. A number of rivers drain these hills, the prominent being the Chenab.

The state of Jammu and Kashmir is made up of three distinct regions viz.:

1. Ladakh—Leh and Kargil
2. Kashmir—Anantnag, Srinagar and Baramula
3. Jammu—Doda, Udhampur, Jammu, Kathua and Poonch.

The valley of Kashmir was once under a vast lake which slowly drained away to expose a fertile plain. The king Kashyapa was the first important ruler of this area. Later on Ashoka the Great and the Mughals contributed towards the overall development of Kashmir. Today, the headquarters of this state are located at Srinagar.

Administrative Units

1. *Kathua* is a small district adjacent to the Gurdaspur district of Punjab. The tract is a plain lying between the rivers Ravi and Tawi.

2. *Jammu* is an important district lying in the foothills. It produces a large quantity of rice and wheat.

3. *Poonch* is located in the foothills to the west of Jammu.

4. *Udhampur* lies at the base of the towering Pir Panjal range.

5. *Doda* is a large district lying in the valley of the river Chenab.

6. *Anantnag* lies in the Kashmir valley. The terrain is almost flat. The district produces a large quantity of paddy and apples.

7. *Baramula* is another densely populated district lying within the Kashmir valley. It is rich in forests. A large quantity of fruits are produced in this district.

8. *Srinagar* is a small but prosperous district lying in the central part of the Kashmir valley. It is a major tourist centre.

9. *Leh* and *Kargil* areas constitute the Ladakh region. It is a cold and dry tract producing meagre crops. Animal husbandry is the main occupation of the people.

Himachal Pradesh

Himachal Pradesh lies to the south-east of Jammu & Kashmir and is a state of the Indian Union. The main physical units of this state have been described below:

(a) *Lahaul valley*: The Lahaul valley lies across the Pir Panjal and main Himalayan ranges, being drained by the rivers Chandra and Bhaga which join to form the Chenab. Keylong is the most important town in

Lahaul valley. Vegetation is sparse and limited to the valleys and along the course of snow-melt waters.

(b) Spiti valley: The Spiti valley is a cold desert lying in the trans-Himalayan tract of the state and drained by the Spiti river which is a tributary of the river Satluj. Kaza is the most important settlement in the Spiti valley. The Spiti valley is virtually devoid of vegetation, it occurs only in valleys and along small streams.

(c) Great Himalaya: The great Himalayan range divides Himachal Pradesh into two unequal parts. It is comprised of high snow-clad peaks, glaciers and deep valleys. The rivers Chenab and Satluj have cut across the main or great Himalayan range in Himachal Pradesh, in their course to the plains. Dense forests cover the lower and middle slopes of this mountain range while the upper tracts may be under a thick cover of snow. Alpine grasslands give way to trees with increasing altitude.

(d) Kullu valley: The river Beas has formed a broad, open valley in Kullu area, within the Pir Panjal range. This valley is very fertile with the lower slopes under agriculture and forests covering the upper tracts. Important towns in this valley are Kullu, Bhuntar and Naggar.

(e) Lower Himalaya: The lower Himalayan range covers a large part of Himachal Pradesh, forming the central and southern part of the state. The slopes are steep while the highest point in the lower Himalaya is Chaur peak, towering to an elevation of more than 3300 mts. on the border of Shimla and Sirmur districts. The main towns of the lower Himalaya of Himachal Pradesh are Shimla, Solan and Mandi.

(f) Shiwalik hills: About one-fourth of the total geographical area of the state is formed by the Shiwalik hills encompassing parts of Sirmur, Solan, Bilaspur, Una, Kangra, Hamirpur and Chamba districts. A number of longitudinal valleys have developed in these hills, e.g. the Kiarda dun valley of Paonta, Una valley and the famous Kangra valley. Important towns in the Shiwaliks are Paonta, Nahan, Parwanoo, Bilaspur, Una, Hamirpur, Nurpur, Dehra and Nadaun.

Himachal Pradesh is well known for its pristine natural beauty formed by gurgling streams, conifer-clad slopes and snow-clad peaks which seem to reach upto the skies. Himachal Pradesh is the *Jalandar Khand* of the *Puranas*. It was visited by travellers from central Asia and Tibet who visited Kulu, Mandi, Rampur, Kangra and the plains of India. The Aryans settled down in the lower hills and in the fertile valleys of the higher Himalaya. The Shimla hills were annexed by the British after the Gorkha

war of 1815-16. After independence, parts of Himachal Pradesh were first constituted into a Union Territory before the present state came into being.

Administrative Units

Himachal Pradesh is divided into the following 12 administrative districts:

1. *Sirmur* is a small district lying in the south-eastern part of the state. The headquarters are at Nahan, a small town located in the Shiwalik hills.
2. *Solan* district extends from the plains of Kalka in Haryana to Chail located on a high ridge.
3. *Shimla* is a large district known for its fruits. It attracts a large number of tourists each year.
4. *Kinnaur* is a border district lying partly in the higher Himalaya and partly in the trans-Himalayan zone. The headquarters are located at Kalpa.
5. *Bilaspur* district is located in the lower hills of central Himachal Pradesh.
6. *Mandi* district extends along the river Beas in central Himachal Pradesh.
7. *Kulu* district is located in a broad valley formed by the river Beas. It produces a huge quantity of fruits. It is also the destination of thousands of tourists each year.
8. *Lahul and Spiti* district encompasses the Lahul and Spiti valleys in the trans-Himalayan zone.
9. *Hamirpur* is a small district located in the foothills.
10. *Una* is another small district located in the foothills.
11. *Kangra* district extends from the plains of Punjab to the imposing Dhauladhar range. The headquarters are located at Dharamsala. It has many other important hill stations like Palampur and Baijnath.
12. *Chamba* occupies the western part of the state. Its northern part is drained by the river Chenab while the rest of the district falls within the catchment of the river Ravi.

Uttarakhand

Uttarakhand or Uttaranchal forms a part of Uttar Pradesh comprising of Garhwal and Kumaun. These hills comprise of the following main physical units:

(a) *Yamuna valley*: This valley is formed by the river Yamuna in the western part of Garhwal, extending from where this river rises from the

Yamunotri glacier to the western fringe of the Dehradun valley in the Shiwalik hills. The river enters the plains near the border of U.P. with Himachal Pradesh.

(b) Bhagirathi valley: The Bhagirathi river is one of the two main rivers, which join at Deoparyag to form the river Ganga. It rises from the Gangotri glacier. The main towns in this valley are Uttarkashi and Tehri.

(c) Alaknanda valley: Rising from the base of the Chowkhamba peak, this river flows in a general southward course to merge with the Bhagirathi river at Deoparyag to form the Ganga river. The main towns in this valley are Karanparyag, Rudraparyag and Srinagar.

(d) Great Himalaya: The great or main Himalayan range is comprised of a gigantic wall of ice, bare rock and rugged peaks, the prominent ones being Nanda Devi, Nanda Kot, Chowkhamba, Shivling, Gangotri and Yamunotri. This mountain range occupies the northern border of Garhwal and Kumaun. Many glaciers of various sizes lie in the great Himalayan mountain wall, the prominent ones being the Yamunotri, Gangotri and Kathling glaciers. Important rivers like the Yamuna, Alaknanda and Bhagirathi rise from this mountain valley. Important towns at the base of the great Himalaya are Joshimath, Badrinath, Gwaldam and Pithoragath.

(e) Lower Himalaya: The lower Himalaya comprise of a series of mountain ranges lying to the south of the great Himalayan mountain wall. This is perhaps the most broadly developed part of Uttarakhand. Important towns of the lower Himalaya are Mussoorie, Tehri, Srinagar, Uttarkashi, Pauri, Nainital, Almora and Ranikhet. Various rivers have cut across the lower Himalayan ranges.

(f) Shiwalik hills: The Shiwalik hills occupy a fairly large tract in Uttarakhand, running along the southern periphery of this region. In the south, these hills merge with the Ganga plains. The tops of the Shiwalik hills may rise to more than 1000 mts. The river Ganga has cut across the Shiwalik hills to enter the plains at Hardwar.

(g) Dun valleys: Longitudinal valleys occur between the main Shiwalik hills in the south and the lesser Himalayan range in the north. Such valleys are known as dun valleys and found all along the foothills of Garhwal and Kumaun, e.g. Dehradun valley. A thick layer of alluvium brought down by rivers from the north and south has been deposited in these fertile valleys.

Garhwal was once a princely state with the headquarters at Tehri. However a part of it was annexed by the British Garhwal. Kumaun attained prominence during the rule of the Chand dynasty. Their headquarters were at Champawat. Garhwal and Kumaun are known for beautiful hill stations like Mussoorie, Ranikhet and Nainital and for places of religious importance such as Badrinath, Kedarnath, Gangotri, Yamunotri, Hemkund and Kalika Devi.

Administrative Units

Garhwal and Kumaun have been divided into the following ten districts:

1. *Dehradun* district lies in the south-western hills of Garhwal. It extends from the crest of the Shiwalik hills to the northern slopes of the Mussoorie ridge.

2. *Tehri* district lies primarily in the catchment of the river Bhagirathi/Ganga. The headquarters are located at Narendranagar. It includes the territory of the former princely state of Tehri.

3. *Pauri* district extends from the plains of Najibabad to the imposing Pauri ridge and along the Alaknanda catchment to Rudraparyag. It is rich in forests.

4. *Chamoli* is the largest district in the U.P. hills. The headquarters are located at Gopeshwar. The entire area of this district falls within the catchment of the river Alaknanda. Its northern border touches that of Tibet. The temple towns of Badrinath and Kedarnath lie in this district. Dense forests occur in this district.

5. *Uttarkashi* district occupies the north-western corner of Garhwal. It is drained by the Yamuna and Bhagirathi river systems. This district is very rich in forests.

6. *Nainital* district occupies the south-eastern part of the Kumaun hills. It is visited by a large number of tourists each year.

7. *Almora* district lies in central Kumaun. It is famous for the production of fruits.

8. *Pithoragarh* district occupies the northern tract of Kumaun. Its borders touch that of Tibet.

9. *Rudraparyag*.

10. *Rudrapur*.

Nepal

Nepal is an independent country forming the central Himalaya, with its

borders touching those of Kumaun, Uttar Pradesh, Bihar, North Bengal, Sikkim and China. It extends from the fringe of the Ganga plains in the south to the Tibetan plateau in the north. Nepal may be divided into the following physical units (after Negi 1994):

(a) Mustang-Bhot region: This is a trans-Himalayan tract in north central Nepal, being largely an arid to semi-arid area receiving very low rainfall.

(b) Great Himalaya: The great Himalayan range extends in an arcuate shape along the northern boundary of Nepal. They extend from the Api and Nampa peaks in the west to the Kangchenjunga peak in the east along the border of Nepal and Sikkim. Mount Everest, the highest peak in the world and the Kangchenjunga massif are a part of the great Himalayan mountain wall. A number of trans-Himalayan rivers have cut across these mountains in Nepal. The main or great Himalaya of Nepal have been divided into the following sub-units by Leban (1972): (i) Western high Himalaya, (ii) Arid high Himalaya, and (iii) Eastern high Himalaya.

(c) Lower and middle Himalaya: This is a wide physiographic unit comprising of the lower and middle Himalayan hills forming the lesser Himalayan region. These are a series of mountains and valleys formed by snow-fed rivers and their tributaries, many of which rise from the glaciers on the main Himalayan mountain wall. The river systems have carved spectacular gorges across the lower and middle Himalayan ranges on their southward course to the plains of India. Major mountain ranges of this physiographic unit are:

- Humla-Jumla mountains
- Baitadi mountains
- Dailekh mountains
- Piuthan mountains
- Beglung mountains
- Mahabharat lekh

(d) Kathmandu valley: This is a flat valley in the middle Himalayan zone of central Nepal, drained by the Bagmati river and its tributaries. Geologists believe that the valley basin was a lake bottom in the past, with the lake having been formed as the Himalaya rising from the seabed blocked the natural drainage. Later the water cut across the mountains and the lake drained, exposing the valley bottom. The capital city of Kathmandu and many smaller towns dominate this valley.

(e) Shiwalik hills: The low rolling Shiwalik hills occupy the southern

tract of Nepal between the Ganga plains and the lesser Himalaya. The tops of these hills rise to elevations of more than 1000 mts. The Shiwaliks are well developed in southwestern Nepal.

(f) *Dun valleys*: Like the adjoining parts of the western Himalaya, longitudinal valleys have formed between the Shiwalik hills and the lower Himalayan ranges of western and central Nepal. These are the Chitwan and Rapti dun valleys covered with alluvium brought down from the mountains on both flanks.

Nepal is known for its unique natural beauty, snow-clad peaks, ravaging torrents, conifer-covered slopes, terraced fields and friendly hill folk. Its economy depends to a large extent on tourism. Kathmandu is the capital of Nepal. It has continued to maintain its status as a buffer between India in the south and China in the north. The people are an admixture of Aryan and Mongoloids. The Gurkha rulers attained prominence during the eighteenth and nineteenth centuries. They invaded the neighbouring areas but were content to remain within their frontiers during the British rule in India.

Administrative Units

- | | |
|----------------|------------------|
| 1. Dharchula | 21. Rolpa |
| 2. Baitadi | 22. Salyan |
| 3. Dandeldhura | 23. Pyuthan |
| 4. Kanchanpur | 24. Dangdoekhuri |
| 5. Bajhang | 25. Mustang |
| 6. Dhoti | 26. Myagadi |
| 7. Kailali | 27. Baghing |
| 8. Bajura | 28. Gulmi |
| 9. Achaam | 29. Arghakanchi |
| 10. Humla | 30. Mananga |
| 11. Mugu | 31. Kapilvastu |
| 12. Dolpa | 32. Parbat |
| 13. Jumla | 33. Kashki |
| 14. Tibrikot | 34. Lamjung |
| 15. Dailekh | 35. Syangja |
| 16. Jagarkot | 36. Tanahu |
| 17. Surkhet | 37. Palpa |
| 18. Bardia | 38. Rupandehi |
| 19. Banka | 39. Nawalparasi |
| 20. Rukum | 40. Gorkha |

- | | |
|---------------------|-----------------|
| 41. Dhading | 59. Sindhuli |
| 42. Chitwan | 60. Khotang |
| 43. Rasuwa | 61. Solokhumbu |
| 44. Nuwakot | 62. Okhladhunga |
| 45. Kathmandu | 63. Sirah |
| 46. Bhaktapur | 64. Udayapur |
| 47. Lalitpur | 65. Saptari |
| 48. Makwanpur | 66. Bhojpur |
| 49. Parsa | 67. Sankhusabha |
| 50. Bara | 68. Dhankuta |
| 51. Rautahat | 69. Terhatum |
| 52. Sarlahi | 70. Sunsari |
| 53. Mahottari | 71. Morang |
| 54. Dhanusha | 72. Ila |
| 55. Sindhupalchok | 73. Taplejung |
| 56. Kavra Palanchok | 74. Panchthar |
| 57. Dolakha | 75. Jhapa |
| 58. Ramechhap | |

Sikkim and Darjeeling Hills

Sikkim is a full-fledged state of the Indian Union while the Darjeeling hills also known as north Bengal forms part of the eastern Indian state of West Bengal. They are comprised of the following physiographic units:

(a) **Foothills:** Low rolling hills have developed along the Ganga-Brahmaputra plains, merging with the lower Himalaya in the north, as the Shiwalik hills are not developed as a separate physiographic entity in the eastern Himalaya. The mountains are broken hills with steep south-facing slopes.

(b) **Lower and middle Himalaya:** The lower and middle Himalaya of this tract comprise of mountains and valleys with a number of prominent ridges that extend for fairly long distances. The Tiger hill is the highest point in the Darjeeling region. The river Teesta has carved a deep gorge across these mountains. Prominent ridges are:

- Gangtok ridge
- Darjeeling ridge from the Tiger hill
- Tadah spur
- Kalingpong ridge
- Ghoom ridge

Important towns in this region are Darjeeling, Kalingpong and Gangtok.

(c) *Great or main Himalaya:* The great or main Himalayan range extends across the northern part of Sikkim between the Kangchenjunga massif in the west and the Chomolhari massif in the east, comprising of many peaks rising to elevations of over 7000 mts. The main Himalaya hold many glaciers and snowy wastes from which rise mighty rivers like the Teesta, rising from the Zemu glacier.

The Darjeeling hills of West Bengal and Sikkim state lie in the western part of the eastern Himalaya. Sikkim came into being as a political entity in 1641 though some of its area was included in the adjoining tracts of Nepal and Bhutan. It remained attached to India by a special treaty of 1950 before finally merging with the Indian Union later on.

Much of the present tract of Darjeeling was a part of Sikkim till 1835 when Darjeeling and Kalingpong were gifted to the Government of British India. This tract is now a part of the state of West Bengal. These hills lie within the Darjeeling district falling in the outer and lower Himalayan ranges. In the southernmost part lies the Siliguri area which is a transition zone between the Himalayan foothills and the plains of north Bengal. The Darjeeling hills lie primarily to the south of the Rangit river. A large number of tourists visit Darjeeling and Kalingpong each year.

Sikkim is bound in the north by Tibet, in the east lies Bhutan, in the west is Nepal and the Darjeeling hills lie to its south. Bose (1972) describes Sikkim in the following words, "Sikkim lying between the Singalila and Dongkya ranges in the west and east, has its northern border along Tibet coinciding roughly with the central Himalayan axis running between Kangchenjunga and Chomolhari (7314 mts) on the Bhutan-Tibet border. The eastern half of this part of the Himalaya lies north of the Chumbi valley in Tibet. This is the only part of the Himalaya which lies exclusively in Tibet. The Chumbi valley south of it is again the only south-sloping valley which takes its rise from the Himalaya and lies in Tibet. . . ." Central and southern Sikkim is densely forested. Gangtok, located on a 1800 mts high ridge is the capital of this state.

Administrative Units

Darjeeling—Darjeeling district.

Sikkim—Gangtok, Mangon, Gyalshing, and Namelu districts.

Bhutan

Bhutan is an independent country occupying a position between India and China (Tibet). It may be divided into the following physiographic units:

(a) **Foothills:** The foothills of Bhutan extend from the Brahmaputra plains in the south to the lower Himalayan mountains in the north. These are low rolling hills, which gradually merge with the lower Himalayan mountains. Phuntsoling is the most important town of the foothills.

(b) **Lower and middle Himalaya:** The lower and middle Himalayan mountains extend from the foothill belt in the south to the great or main Himalaya in the north. Mountains, ridges, V-shaped valleys, interlocking spurs and terraced river basins are its prominent features. The average elevation varies from 1200 to 2200 mts. with mountain tops rising to elevations of over 3000 mts. Important towns of this physiographic unit are Paro, Thimpu and Confluence.

(c) **Great or main Himalaya:** The great or main Himalayan range is comprised of an arc of snow-clad mountains stretching from the Chomolhari peak to the Kulha Kangri peak. Many snow-fed rivers descend from the slopes of these mountains. The population is very sparse, and only shepherds visit the region in the summer season.

Bhutan lies within the eastern Himalaya. Its northern boundary touches Tibet while to its west lies Sikkim; in the east is Arunachal Pradesh and the Brahmaputra plains lie to its south.

The history of Bhutan is not very clear till the end of the eighteenth century. Till that time, Bhutan was a loose confederation of tribal chiefs. Today, the country is undergoing modernisation. Bhutan is ruled by a king whose seat is at Thimpu, the national capital.

Northern Bhutan consists of a great area of snowy peaks from which descend snow-fed rivers. This mountain wall extends from the Chomolhari (7314 mts) in the west to the Kulha Kangri (7541 mts) and further towards west to the Bhutanese border with Arunachal Pradesh. The population of northern Bhutan is very sparse. There are a few forts (*dzongs*) and monasteries. Shepherds migrate to the alpine meadows during the summer months.

Central Bhutan is thickly forested. It is made up of V-shaped valleys, terraced river basins and high mountain ridges. Most of the rivers have carved spectacular gorges through the lower Himalayan mountain ranges. The towns of Thimpu and Paro are located in central Bhutan.

Southern Bhutan is densely populated. It is made up of the low rolling Shiwalik hills and the foothills of the lower Himalaya. A number of important commercial centres lie in this tract. These include the town of Phuntsoling on the Indo-Bhutan border. It lies on the main entry point into Bhutan.

The economy of Bhutan is based primarily on agriculture. The people living at higher elevations depend on animal husbandry for their livelihood. Buddhism is the main religion of this country.

Administrative Units

Bhutan is divided into the following administrative districts:

- | | |
|--------------|--------------------|
| 1. Chirang | 10. Pemaghatshal |
| 2. Daganna | 11. Samchi |
| 3. Gasa | 12. Jongkhar |
| 4. Geylephug | 13. Shemgang |
| 5. Ha | 14. Tashigang |
| 6. Jakar | 15. Thimpu |
| 7. Lhuntshi | 16. Tongas |
| 8. Momgar | 17. Wangdiphodrang |
| 9. Paro | |

Arunachal Pradesh

Arunachal Pradesh is a state of Indian Union, occupying the easternmost part of the Himalayan mountain system. It is comprised of the following physiographic units:

(a) Foothills: The foothills of Arunachal Pradesh merge with the Brahmaputra plains in the south and extend to the lower and middle Himalayan hills in the north.

(b) Lower and middle Himalaya: The lower and middle Himalayan ranges of this state are physically akin to other parts of the eastern Himalaya. They consist of a series of mountains that have been cut across by many rivers rising from the snow-fed mountains to the north. Important towns are Tezpur and Itanagar.

(c) Great or main Himalaya: The great or main Himalayan range extends along the northern periphery of Arunachal Pradesh of which the Kangto group of peaks is a part. Glaciers and snowy wastes occur on the upper slopes of these mountains.

Arunachal Pradesh lies between Bhutan in the west and Brahmaputra valley in the east. It was a remote area till the Chinese invasion of 1962. Since then it was developed at a very fast pace. The northern part of this state is made up of snow-bound peaks of the great Himalayan mountain wall. Central Arunachal Pradesh is rugged and densely forested, while the southern part of this state consists of low rolling hills covered by moist forests.

Administrative Units

Arunachal Pradesh is divided into the following five administrative districts:

1. Kameng district
2. Subansiri district
3. Siang district
4. Lohit district
5. Tirap district

DRAINAGE

The Himalaya is drained by an intricate network of rivers and streams. These belong to the following three major river systems:

Indus System

The *river Indus* rises in the Tibetan plateau and enters the Himalaya in Ladakh. It makes a sharp bend south of lake Pangong and cuts across the main Ladakh range near its confluence with the river Shyok. The river Indus flows in a more or less NW direction before it turns around the base of the Nanga Parbat massif. The main course of this river in Ladakh is confined to a relatively narrow channel though it does form broad plains. The major tributary systems which join the river Indus in Ladakh are the Shyok, Shigar and Gilgit on the right bank and the Astor, Shigar (south), Zaskar and Hanle on the left bank.

The *river Jhelum* is the westernmost of the five major tributaries of the river Indus. It originates on the northern slopes of the Pir Panjal range which hems the Kashmir valley. A major tributary of the Jhelum, the Liddar, rises from the foot of the main Himalayan range. The river Jhelum and its tributaries drain the entire Kashmir valley before flowing through a narrow gorge in the Pir Panjal range to emerge in the plains. The other

major tributaries of the Jhelum are the rivers Sindh and Kishenganga.

The *river Chenab* is formed primarily by the rivers Chandra and Bhaga, both of which originate on the north-western slopes of the great Himalayan range. Both these rivers flow through a very sparsely inhabited tract before joining to form the Chenab. This river flows through the famous Pangi tract of Himachal Pradesh. Its main northern bank tributaries are the Saichu and the Miyar streams. The Chenab cuts across the Pir Panjal range and flows for a considerable distance along its base before entering the plains.

The *river Ravi* is another important tributary of the river Indus. It is formed by two snow-fed streams, the Bhadal and the Tant Giri. The river Ravi flows in a more or less westerly direction before it cuts across the Dhauladhar range to enter the plains of Punjab. It flows past the town of Chamba in Himachal Pradesh and divides the district into two unequal halves.

The *river Beas* rises on the southern slopes of the main Himalaya below the famous Rohtang pass. It flows past the famous holiday resort of Manali and then cuts across the Dhauladhar range at Larji. The main tributaries of the Beas before it passes through the Dhauladhar range are the rivers Parbati, Harla, Sainj and Tirthan. The rivers which join the Beas in the foothills are the Uhl, Suketi, Luni, Awa, Banganga, Gaj and Chakki. The *river Satluj* is the largest tributary of the river Indus. It rises near the lake Mansarovar in Tibet and flows for a considerable distance before entering the Himalaya near Shipki La. Thereafter, it drains past the trans-Himalayan zone of Spiti where it is joined by the Spiti river. The Satluj has cut across the great Himalayan range through a deep gorge. Just upstream of this gorge, it is joined by the river Baspa. After crossing the great Himalayan range, the river Satluj flows in a more or less south-west direction before emerging into the plains of Punjab.

Ganga System

The Ganga system drains a major part of the Himalaya. Its basin extends from the eastern slopes of the Shimla ridge to eastern Nepal.

The *river Yamuna* is the largest tributary of the Ganga system. It drains the westernmost part of the Ganga catchment. The Yamuna river rises from the Yamunotri glacier in Uttarkashi district. It flows for a considerable distance in a south-westerly direction before turning towards west. Its main tributaries are the Tons, Aglar, Giri and Bata.

The *river Bhagirathi* is one of the two rivers which merge to form the mainstream of the river Ganga. It rises from the snout of the Gangotri glacier in Uttarkashi district. Thereafter it winds its way past the towns of Uttarkashi and Tehri before merging with the river Alaknanda at Deoparyag in the lower Himalaya of Garhwal. The river Bhilangana is the largest tributary of the river Bhagirathi. It rises from the Kathling glacier in the higher Himalaya of central Garhwal. The main tributaries of the river Alaknanda are the Mandakini, Pindar, Nandakini and Dhauliganga. Each of these tributary rivers drains a fairly large area.

The main stream of the *river Ganga* flows for a relatively shorter distance in the Himalaya before it emerges into the plains near Hardwar. The river Song, which drains the eastern part of Dehradun valley joins the river Ganga near Rishikesh.

The *river Kali* and its tributaries drain the eastern part of Kumaun and parts of western Nepal. This river forms the border between India and Nepal. There are two headwaters of the river Kali—the Kalapani, the eastern headwaters which is a collection of springs, and the Kuthi Yankti, the western headwaters that rise in the snowfields of the Himadri on the southern slopes of the main Himalayan range.

The river Kali flows in a more or less SSW direction along a narrow V-shaped valley before it debouches into the plains. Its main tributaries are the river Gori Ganga which rises from the eastern snowy slopes of the Kali-Alaknanda waterdivide; the river Sarju which drains central Kumaun, the river Ladhiya which is formed by a number of streams in the south-eastern corner of Kumaun, the river Lohawati and a number of eastern bank tributaries draining parts of Nepal.

The *river Ramganga* is a tributary of the river Ganga which drains parts of south-western Kumaun. It is formed by a number of streams which join the main river which drains through a V-shaped valley, past the broad terraced fields of Ganai and through the dense foothill forests of Corbett National Park to enter the plains.

The *river Ghagra* and its tributaries drain western Nepal. It has a number of large tributaries:

- (a) the river Karnali rises in the springs of Mepha Chungo near Mansarovar in Tibet. Thereafter, it flows south of the Gurla Mandatta, cuts across the great or main Himalayan range to enter Nepal.
- (b) the river Seti rises near Api and flows in an easterly direction to join the Karnali.

- (c) the river Bheri rises in the snows of the Dhaulagiri massif and joins the river Ghagra in the foothills.

The *river Gandak* and its tributaries drain central Nepal. The main river of this system is the Krishna Gandaki which rises in the trans-Himalaya tract beyond Manang Bhot. It has cut across the main or great Himalayan range through a spectacular gorge between the Dhaulagiri and Annapurna massifs. The other important tributaries of the Gandak river system are the Seti Gandak which rises from the base of the Ganesh Himal.

The *river Kosi* and its tributaries drain eastern Nepal. The main river is known as the Sapt Kosi in its upper reaches as it is formed by the following seven major rivers:

- (a) the river Sun Kosi which rises beyond the Gosainthan massif.
- (b) the Indrawati which drains the eastern outer rim of the Kathmandu valley.
- (c) the Bhola Kosi which takes away the snow-melt waters of the Cho Oya and the Gauri Shankar massifs.
- (d) the river Dudh Kosi drains the Mount Everest massif.
- (e) the river Arun rises in the trans-Himalayan zone of Tibet. It has cut across the main Himalayan range through a fantastic gorge to the east of the Everest massif.
- (f) the river Barun rises from the Barun glacier lying at the base of the Makalu peak. It drains into the river Arun.
- (g) the river Tamur is the eastern tributary of the river Kosi. It rises from the snowy wastes on the western flank of the Kangchenjunga group of peaks known as the Kumbhkaran Himal.

Brahmaputra System

The Brahmaputra system drains the eastern Himalaya. This river ranks amongst the longest rivers of the world. It rises in the great glacier of the Kailash range and flows for a distance of about 1700 kms towards east in Tibet as the river Tsang po. Thereafter, it makes U-turn at the base of the Namche Barwa peak and enters India as the Brahmaputra. This river is joined by tributaries draining both the mountains of the eastern Himalaya and the hills falling within the other parts of north-east India.

The *river Teesta* is a large tributary of the Brahmaputra. It rises from the Zemu glacier at the base of the Kangchenjunga massif. Thereafter, it

flows towards south before merging with the Brahmaputra in the plains. The river Teesta has formed a deep valley which divides the Darjeeling and Kalingpong hills. The main tributaries of this river are the Lhonak which rises in the snowy wastes of north Sikkim, the river Lachung rising from the Pahunri and the river Rangit which is also fed by glaciers on the slopes of the Kangchenjunga massif.

The *river Torsa* is another tributary of the Brahmaputra. It enters Bhutan from the Chumbi valley as the river Amo Chhu. Thereafter, it drains south-western Bhutan and enters the plains near the foothill town of Phuntsoling.

The *Raidak river* drains western Bhutan. Its main tributaries include the river Thi Chhu which rises in the snows at the base of the great Himalayan range; the river Paro Chhu which is joined by the Thi Chhu at Confluence and the river Ha Chhu which flows in a south-easterly direction and joins the main river between Confluence and Chukho.

The *river Sankosh* is another important tributary of the Brahmaputra. It rises as the Mo Chhu north of Gase Dzong in the snowy wastes of the main or great Himalayan range. It drains past the towns of Punakha and Wangdu Phodrang to enter the plains of north Bengal.

The *Manas river* and its tributaries drain parts of central and eastern Bhutan. The important tributaries of this river are: (a) the river Mangde Chhu which drains central Bhutan; (b) the river Chanka rises from the snows on the southern slopes of the main Himalayan range of Bhutan. It joins the river Mangde Chhu; and (c) the river Kurd.

The *river Kameng* is another important Himalayan tributary of the river Brahmaputra. It drains parts of Arunachal Pradesh. This river rises in the Kangto group of peaks. Its main tributaries are the Bichom and Tenga.

The *river Subansiri* is a major tributary of the Brahmaputra. It drains a large part of Arunachal Pradesh. This river has a vast catchment in the trans-Himalayan zone of Tibet. It has cut across the main Himalayan range through a spectacular gorge. Two of its main tributaries which originate in Tibet are the Yuma Chhu and the Chaval Chhu.

GLACIERS

A large number of glaciers occur on the slopes of the main and trans-Himalayan ranges. Smaller glaciers are found on other ranges such as the Pir Panjal and the Dhauladhar. The elevation to which Himalayan

glaciers may descend varies with the following conditions:

- the total annual precipitation that is received in the form of snow
- latitude
- topography and aspect.

Himalayan glaciers descend to lower elevations in Kashmir than compared to those occurring in Sikkim or Arunachal Pradesh. This has been brought out in the following table.

Region	Avg. lowest elevation (in mts)
Kashmir	3700
Himachal Pradesh	3900
Garhwal & Kumaun	4000
Nepal	4200
Sikkim	4300
Bhutan	4300
Arunachal Pradesh	4350

Von Weissmann (1959 as cited by Vohra 1981) has estimated that an area of about 32,000 square kilometres of the Himalaya is under a permanent cover of ice. This amounts to about 17 per cent of the total geographical area of the Himalaya. The areas of higher concentration of glaciers in the Himalaya lie in the tracts having the highest mountain peaks. The following table shows the average length of the main glaciers in the Himalaya.

Glacier	Average length (in kms)
Siachen (Kashmir)	72
Biafo (-do-)	62
Hispor (-do-)	61
Baltoro (-do-)	58
Gangotri (Garhwal)	26
Zemu (Sikkim)	26
Milam (Kumaun)	19
Kedarnath (Garhwal)	14

An outstanding feature of the glaciers in the Himalaya is that many of them are shrinking or retreating. The Pindari glacier has shrunk by nearly 3 kms in the past 150 years while the Siachen glacier has shrunk by about 1 km in the past 50 years. However, recent data collected from the few Himalayan glaciers which are kept under annual observation

suggests that there has been a considerable slowing down in the recession of these glaciers. Bhandari and Nijampurkar (1981) state, "The studies found that most glaciers have a negative mass balance during the past decade that is more ice is melting than the snow is accumulating. That glaciers have been receding is also evident because several tributaries once connected with the main body of glaciers are now disconnected—a consequence of the severe negative mass balance . . ."

NATURAL VEGETATION

The Himalaya are extremely rich in natural vegetation, which comprises mainly of forests and grasslands. Though the natural vegetation found in the Himalayan region has been described in detail in a separate chapter, the principal forest/natural vegetation types have been listed below:

1. *Sub-tropical semi-desert forests*

- (a) Dry open forests
- (b) Dry open scrub

2. *Sal forests*

- (a) Shiwalik sal forests
- (b) Dry sal forests
- (c) Terai and bhabar sal forests
- (d) Dun sal forests
- (e) Lower Shiwalik sal forests

3. *Montane sub-tropical forests*

- (a) East Himalayan sub-tropical wet hill forests
- (b) Shiwalik chir pine forests
- (c) Lower Himalayan chir pine forests
- (d) Sub-tropical dry evergreen forests
- (e) Sub-tropical riverine forests
- (f) Sub-tropical wet evergreen forests

4. *Montane wet temperate forests*

- (a) East Himalayan semi-evergreen forests
- (b) East Himalayan wet temperate forests
- (c) High level oak forests
- (d) Lauraceous forests

5. *Moist Himalayan temperate forests*

- (a) Ban oak forests

- (b) Moru oak forests
- (c) Moist deodar forests
- (d) Moist mixed coniferous forests
- (e) Moist blue pine forests
- (f) Kharsu oak forests
- (g) High level fir and spruce forests
- (h) Western Himalayan upper oak fir forests
- (i) East Himalayan mixed coniferous forests
- (j) East Himalayan temperate forests
- (k) *Abies delavayi* forests

6. *Himalayan dry temperate forests*

- (a) Dry broad-leaved and coniferous forests
- (b) Neoza or Chilgoza pine forests
- (c) Dry deodar forests
- (d) West Himalayan dry temperate forests
- (e) West Himalayan high level dry blue pine forests
- (f) West Himalayan dry juniper forests
- (g) East Himalayan dry temperate coniferous forests
- (h) East Himalayan dry juniper forests

7. *Sub-alpine forests*

- (a) West Himalayan sub-alpine birch/fir forests
- (b) Sub-alpine fir and spruce forests
- (c) East Himalayan sub-alpine birch/fir forests

8. *Moist alpine scrub*

- (a) Birch-Rhododendron scrub forest
- (b) Deciduous alpine scrub
- (c) Alpine pastures

9. *Dry alpine scrub.*

GEOLOGY

The Himalaya is one of the youngest mountains in the world. The mountains of peninsular India, viz. the Aravalis, Satpuras and Vindhyan are over 1000 million years old while the Himalaya are only 40 million years old.

Origin of the Himalaya

The surface of the earth has been undergoing complex changes that have

given rise to the present configuration. These processes are still going on today and thus the face of the earth is slowly changing. The Himalaya is one of the many mountains that have originated in a vast sea-basin bordering a landmass. Other major mountain systems believed to have born under the sea include the Alps and the Andes.

The tethyan sea in which the Himalaya is believed to have originated lay between two major landmasses—the Gondwana land (present day peninsular India) in the south and the Angaraland (the central Asian landmass) in the north. Rivers deposited millions of tons of sediment into this sea which resulted in a slow subsidence of the bottom of this basin. After a certain period of time the basin became so deep that it came in contact with the hot interior of the earth. The load of the sediments led to a compaction of the lower layers.

There began a series of movements towards the close of the mesozoic era which led to the emergence of the Himalaya from under the tethyan sea. The Himalaya was formed due to a series of distinct phases of uplift. The first uplift is believed to have occurred towards the end of the Eocene era and continued till about the middle of Oligocene times. The sea waters soon drained away and the central axis of the rising mass of sediments elevated to form a mountain chain. A trough or basin was formed in the south of this rising mountain chain which continued to deposit sediments. This trough gave birth to the Shiwalik hills.

The second phase of upheaval occurred from middle Miocene to the end of Pliocene. It resulted in the further elevation of the central axis and the lower Himalaya. The Shiwalik hills to the south are also believed to have risen out of the trough during this phase of uplift.

The last phase of upheaval took place towards the end of the Pleistocene times. It gave this mountain chain its present geomorphic form. A trough formed towards the south of the rising Shiwalik hills was filled by sediments to form the vast Indo-Ganga plain. The Himalaya are still rising.

Based on lithology and structure, the Himalaya are divided into the following four geological belts.

1. Shiwalik Himalaya or Sub-Himalaya

The rocks of the Shiwalik Himalaya are relatively very young. They consist of sandstones conglomerate beds, quartzites and more or less unconsolidated sediments made up of cobbles, shingles, pebbles, gravels and boulders. Fossils of dinosaurs are found in the upper horizons of the

Shiwalik sequence. The Shiwalik rocks are usually in contact with the sediments of the Indo-Ganga plain along prominent fault zones.

2. *Lesser or Lower Himalaya*

The older lesser or lower Himalayan rocks have been brought to lie over the young Shiwalik rocks by a deep-seated thrust fault which runs all along the lower zone of the Himalaya. This is known as the main central thrust. The lesser or lower Himalayan rocks consist of phyllites, shales, slates, quartzites, limestones and dolomites. These have been intruded by vast bodies of igneous rock such as granites and metabasics.

3. *Higher or Central Himalaya*

The rocks of the higher or central Himalaya are usually collectively referred to as the central crystallines. They are older in age than those of the lesser or lower Himalaya but they overlie the latter due to a deep-seated thrust fault known as the main central thrust. The rocks are highly metamorphosed and consist of marbles, quartzites, gneiss and schists which have been intruded by igneous bodies such as granites and metabasics.

4. *Trans or Tethyan Himalaya*

The rocks occurring in the trans-Himalayan zone are usually referred to as the tethyan sequence. These consist of shales, phyllites, limestones, siltstones, claystones, boulder beds, quartzites and schists which have been intruded by granites and basic igneous rocks. The tethyan Himalayan rocks are very rich in both animal and plant fossils.

SOILS

The nature and type of soils found in the Himalaya varies from place to place, and along with it changes the vegetation it supports. The nature and composition of the soil depends upon the parent or country rocks; prevailing climatic conditions; topography and the vegetation growing on it. The Himalayan soils vary from the rich and deep alluvial soils of the *terai* and *bhabar* tract to the thin and bare soils of the high mountains and the almost desert-like soils of the trans-Himalayan zone. The major soil types found in the Himalaya are:

Himalayan Alluvial Soil (group A)

These are alluvial, riverine, non-calcerous to moderately calcerous

soils. Well developed in the dun valleys and in the *terai-bhabar* tract.

Himalayan Alluvial Soil (group B)

These are alluvial riverine soils of recent origin. Well developed along rivers, streams and on recently formed terraces.

Red and Black Soil

These soils are reddish brown to dark brown deficient in humus and lime. Found over acidic rocks in the lower Himalaya.

Ferruginous Red Soil

These soils are free of carbonates, light-textured, porous and friable. Well developed all over the eastern Himalaya.

Brown Soil

These soils are found in extensive tracts under dense temperate forests. The upper layer is very rich in humus.

Forest Soil

These soils are formed by a number of typical Himalayan soils found under forests that are largely undisturbed by human activity.

Brown Forest Soil

This is also made up of a number of soils varying from acidic to neutral soils found under pastures to those found under almost virgin forests.

Podsollic Soil

These are black to brown soils with a distinctly leached upper horizon. Well developed in different parts of the Himalaya.

Himalayan Foothill/Terai Soil

This soil is formed in the foothill/terai zone. These soils are acidic with colour varying from deep black to greyish black.

Mountain and Hill Soil

This is a collective name given to soils occurring at high elevation under temperate and arctic conditions. A rich layer of humus is present on the upper layer.

High Altitude Meadow Soil

Found near the snowline in all parts of the higher Himalaya. These soils are very thin and fragile.